



Flame Retardants: Integral to Fire Safety

## **Fire Behaviour of Household Appliances towards External Ignition**

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# Introduction

- The European Flame Retardant Association (EFRA) sponsored a series of fire tests of household appliances
- The tests were carried out in view of:
  - Recent developments in IEC with TS 62441 „Accidentally caused candle flame ignition“
  - A potential revision of the European Low Voltage Directive. A draft revision text mentions adequate resistance to external ignition as a requirement.
- The aim of the test was to investigate, if and how current appliances will burn when exposed to a small flame.



The IEC TS 62441  
needle flame

# The Test Specimens

- All specimens were purchased from a local electronics store and were new, mid-price range items from well known brands (European and Japanese)
- The specimens should represent typical items currently on the market:
  - Coffee Machine
  - Two Micro-Stereos
  - Air Conditioner
  - Tumble Dryer
  - Refrigerator
- Brand names are not revealed in this report, because the aim was not to target specific brands, but to study the general fire behaviour of these items.

# Specimen Details

Item	Weight	Materials	Size [mm]	Weight post burn [kg]	Weight Loss [kg]
Coffee machine	1.44 kg + 0.3 kg glass pott	PP	32 x 20 x 24	0.62	1.12
Micro Stereo P	2.7 kg + 2.2 kg for speakers	HIPS, speakers: fibre board	148 x 235 x 258		
Micro Stereo G	2.4 kg + 2 * 0.85 kg speakers	HIPS (also speakers)	170 x 172 x 250		
Air Conditioner	34.9 kg - 0,4 kg refrigerant + 1,1 kg nozzle	Covers: ABS, PS-foam inside	466 x 855 x 406	26	8.9
Tumble Dryer	40 kg	Housing: steel, front parts + door covering: ABS, inside door: PP GK20 / TPE, condenser: PPK55, tank at top: HDPE	850 x 600 x 600	29	11
Refrigerator	43.7 kg + x refrigerant	Covers: steel, inside: PS, insulation: PUR (likely), ignited part: PP	1130 x 552 x 657	26	18



# The Fire Laboratory

- Tests were carried out at the BayerIndustryServices facility in Leverkusen, Germany
- The tests were done under the ISO 9705 room corner hood.
  - Heat release was determined by oxygen depletion.
  - Smoke density was measured by optical absorption.



The ISO 9705  
test hood

# Credits

- The tests were carried out with the help of
  - BayerIndustryServices:
    - Michael Halfmann
    - Frank Volkenborn
    - Volker Kelter
  - University of Wuppertal:
    - Wilhelm Wittbecker
  - EFRA:
    - Adrian Beard
    - David Buszard
    - Sieghard Göbelbecker
    - Sander Kroon
- The photos in this document are © EFRA, Ralf Baumgarten, 2006  
[www.ralfbaumgarten.de](http://www.ralfbaumgarten.de)





# Results - Summary

Type	RHR max [kW]	time of RHR max [s]	Total Heat Release [MJ]	max. Absorption [%]	SPR [m <sup>2</sup> /s]	time SPR max. [s]	TSP [m <sup>2</sup> ]
Coffee machine	44	587	33	29	0.6	1737	321
Micro Stereo P	70	381	65	64	1.9	525	1388
Micro Stereo G	76	194	52	88	3.6	627	2434
Air Conditioner	299	205	212	93	9.9	633	8682
Tumble Dryer	540	262	253	59	4.6	843	1858
Refrigerator	852	665	432	98	17.7	2052	9522

- All items caught fire easily upon contact with the needle flame which could be withdrawn after 30 ... 180 sec.
- All fires went on for a long time (> 30 min) with maximum heat release rate between 44 and 850 kW.
  - Fires were extinguished when they were dying down (> 30 min)
  - Heat release was probably under-estimated due to some smoke loss because of the hood configuration.



# Coffee Machine (0)





# Coffee Machine (1'01)



01:01 min:sec after ignition



03:31 min:sec after ignition

# Coffee Machine (5'14)



05: 14 min:sec after ignition



06: 12 min:sec after ignition

# Coffee Machine (11'25)



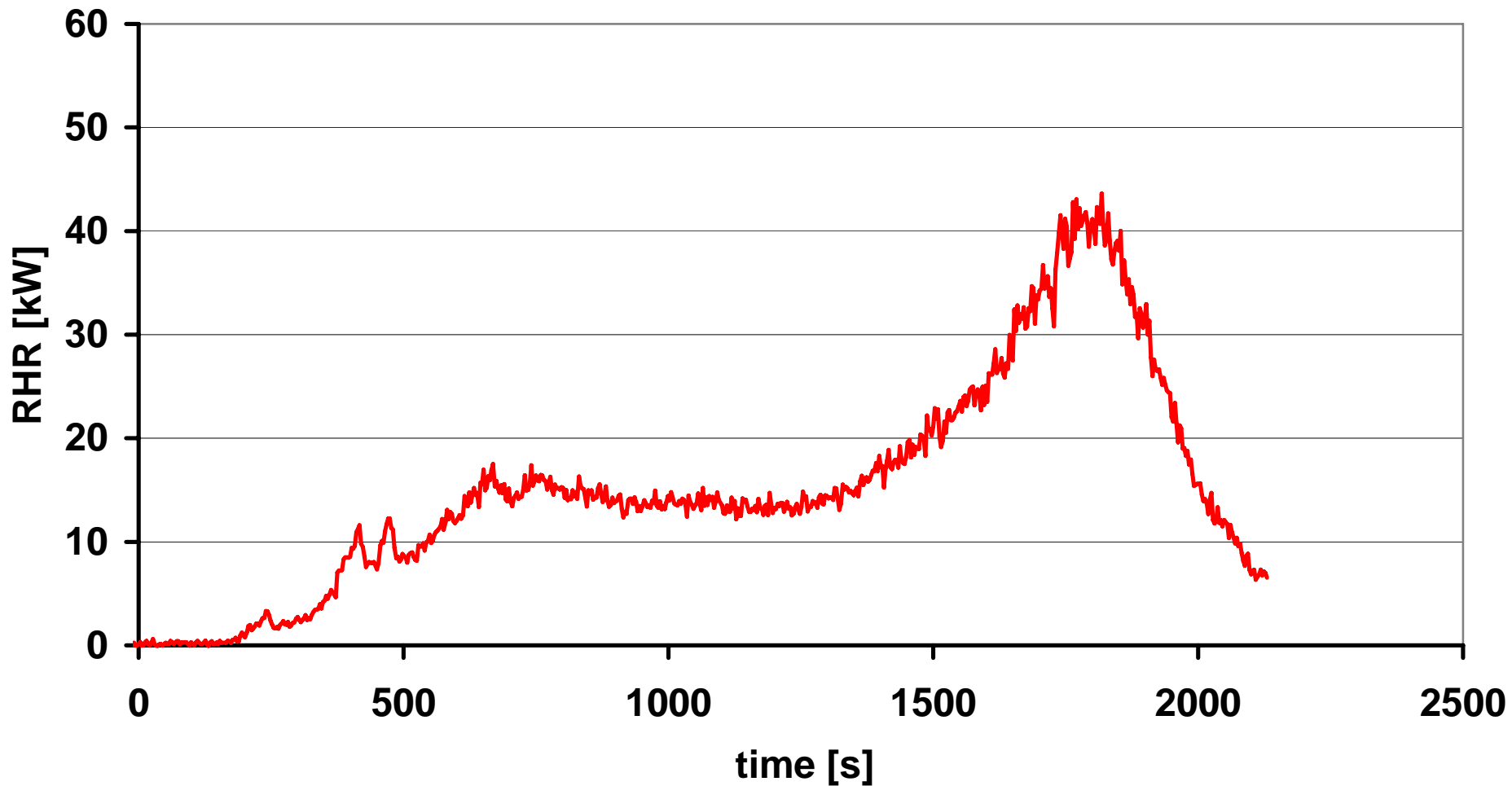
11:25 min:sec after ignition

# Coffee Machine (26'01)



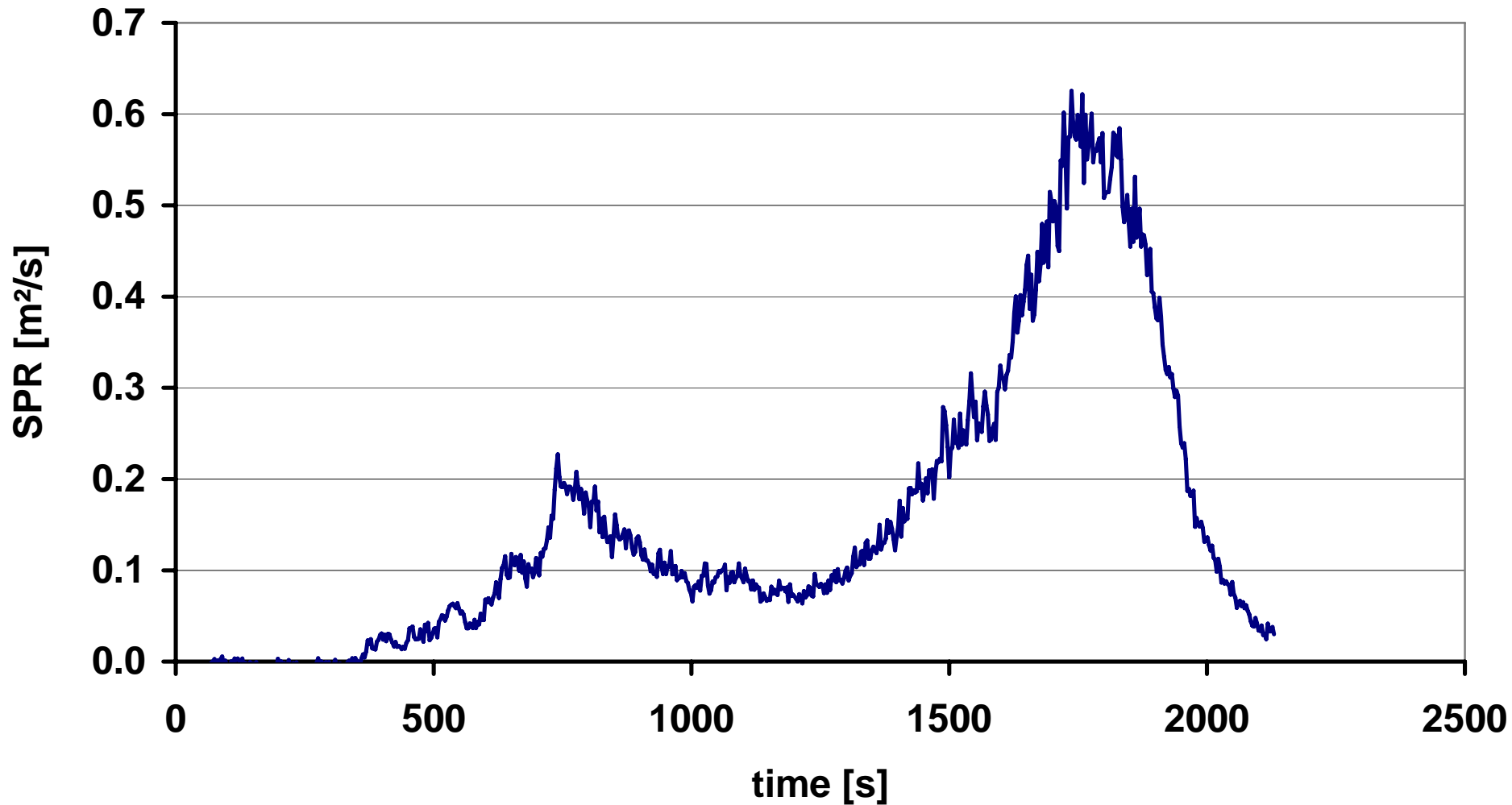
26:01 min:sec after ignition

# Coffee Machine – Heat Release

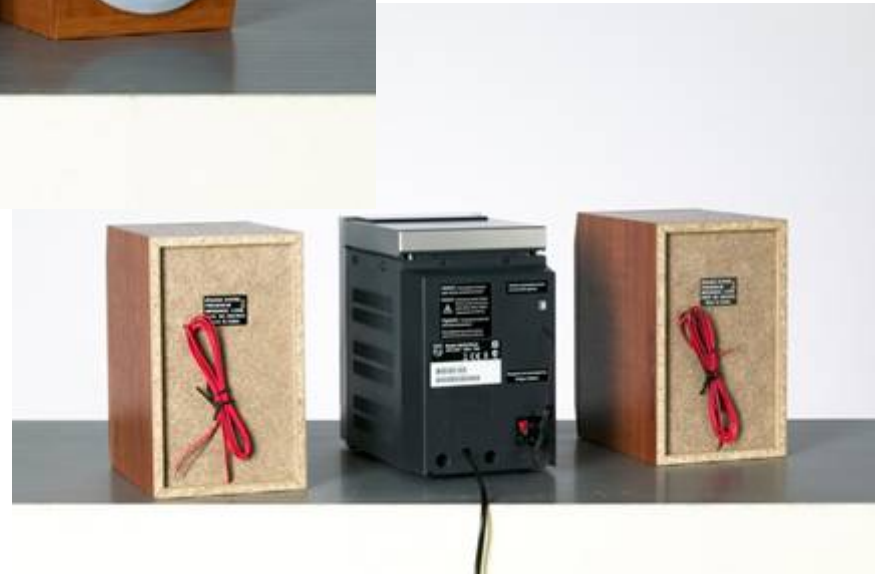




# Coffee Machine – Smoke Production



# Micro Stereo P (0)





# Micro Stereo P (1'22)



01:22 min:sec after ignition

# Micro Stereo P (3'17)



03:17 min:sec after ignition

# Micro Stereo P (4'34)



04:34 min:sec after ignition

# Micro Stereo P (6'09)



06:09 min:sec after ignition



# Micro Stereo P (21'03)



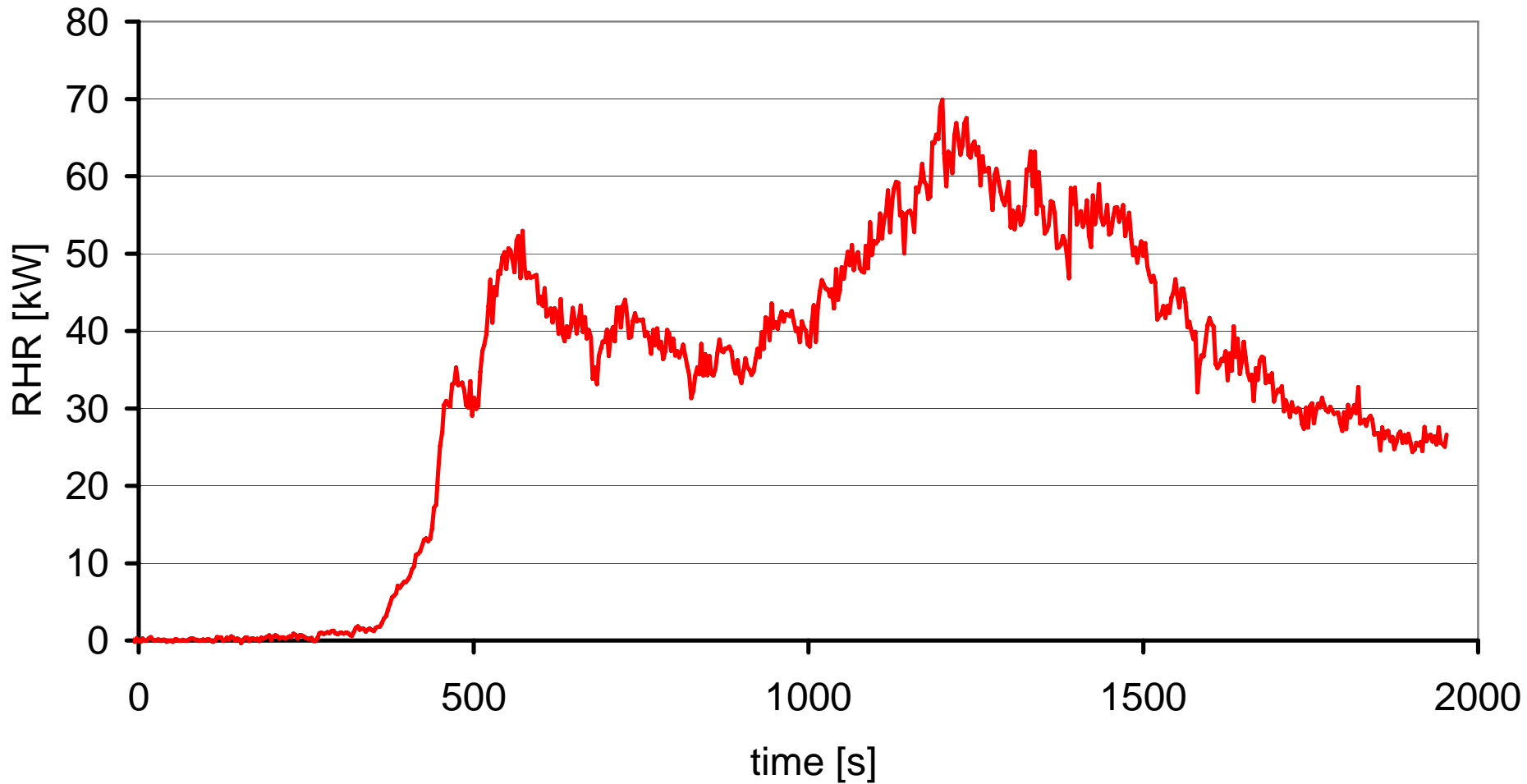
21:03 min:sec after ignition

# Micro Stereo P (39'59)



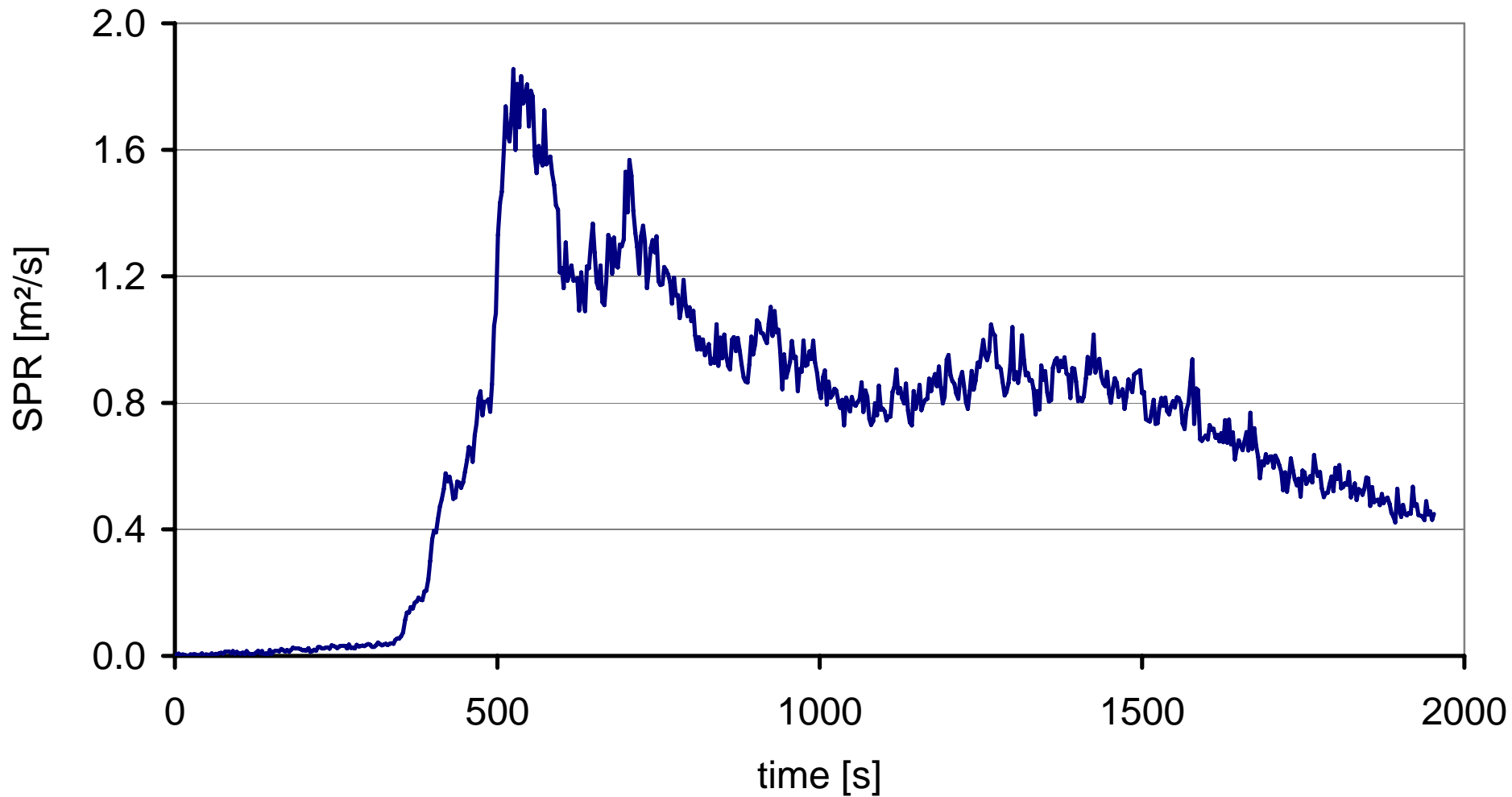
39:59 min:sec after ignition

# Micro Stereo P – Heat Release





# Micro Stero P – Smoke Production



# Micro Stereo G (0)



# Micro Stereo G (1'49)



01:49 min:sec after ignition

# Micro Stereo G (3'34)



03:34 min:sec after ignition

# Micro Stereo G (5'42)



05:42 min:sec after ignition

# Micro Stereo G (6'36)



06:36 min:sec after ignition



08:59 min:sec after ignition



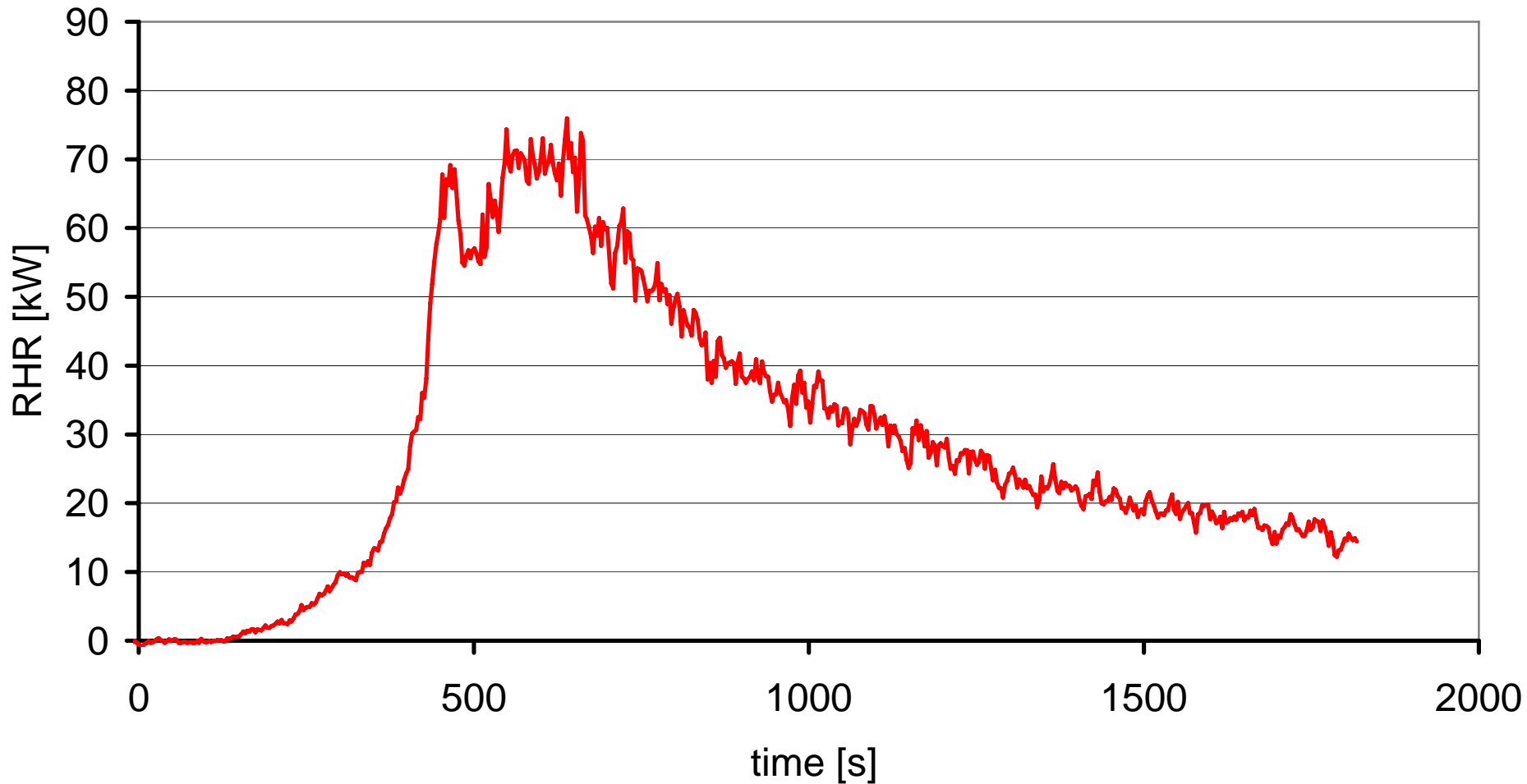
# Micro Stereo G (13'28)



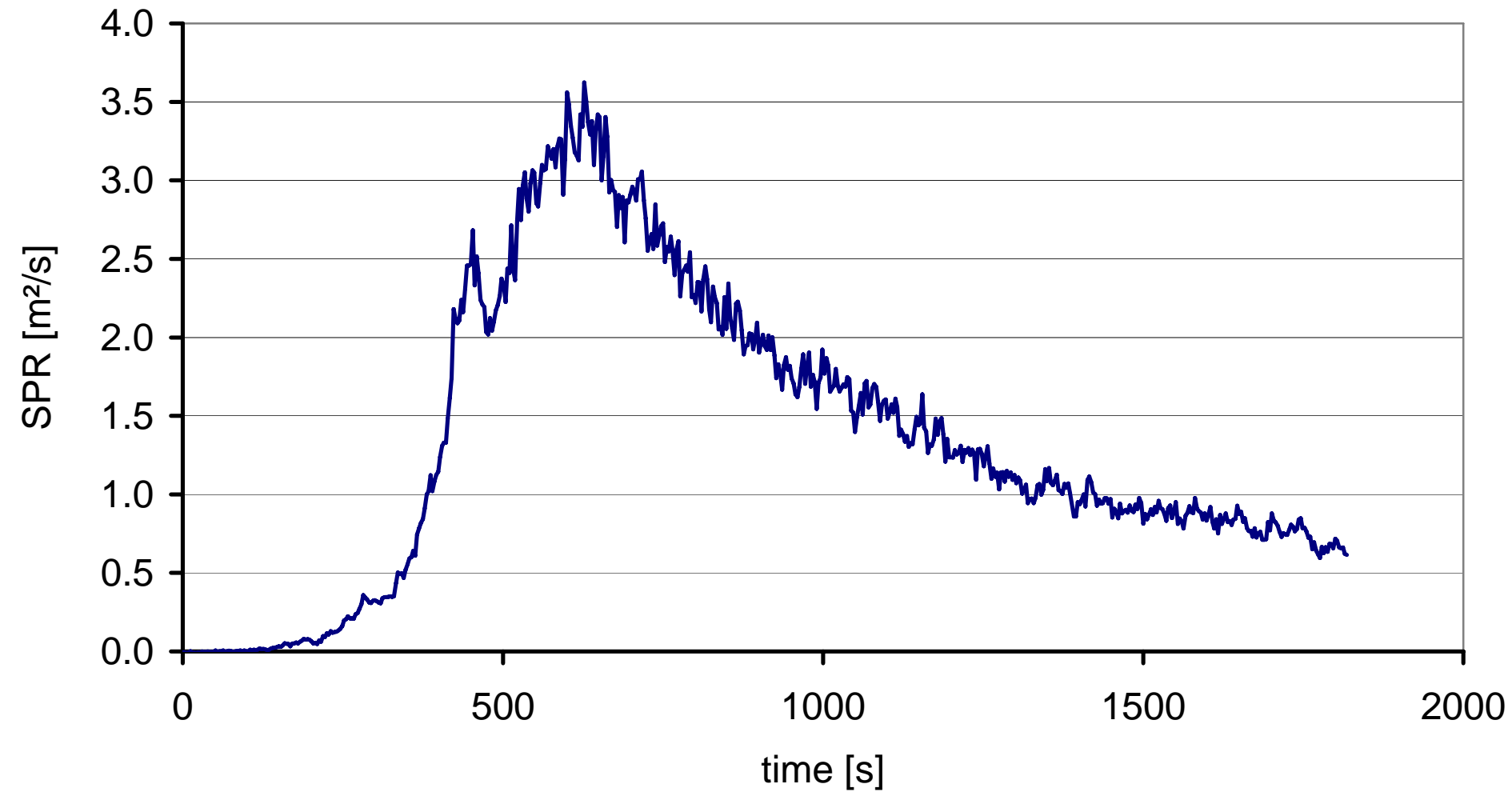
13'28 min:sec after ignition



# Micro Stereo G – Heat Release



# Micro Stereo G – Smoke Production



# Air Conditioner (0)



# Air Conditioner (1'49)



00:01 min:sec after ignition



01:49 min:sec after ignition

# Air Conditioner (2'29)



02:29 min:sec after ignition



04:55 min:sec after ignition

# Air Conditioner (7'32)



07:32 min:sec after ignition



09:22 min:sec after ignition



# Air Conditioner (14'21)



14:21 min:sec after ignition



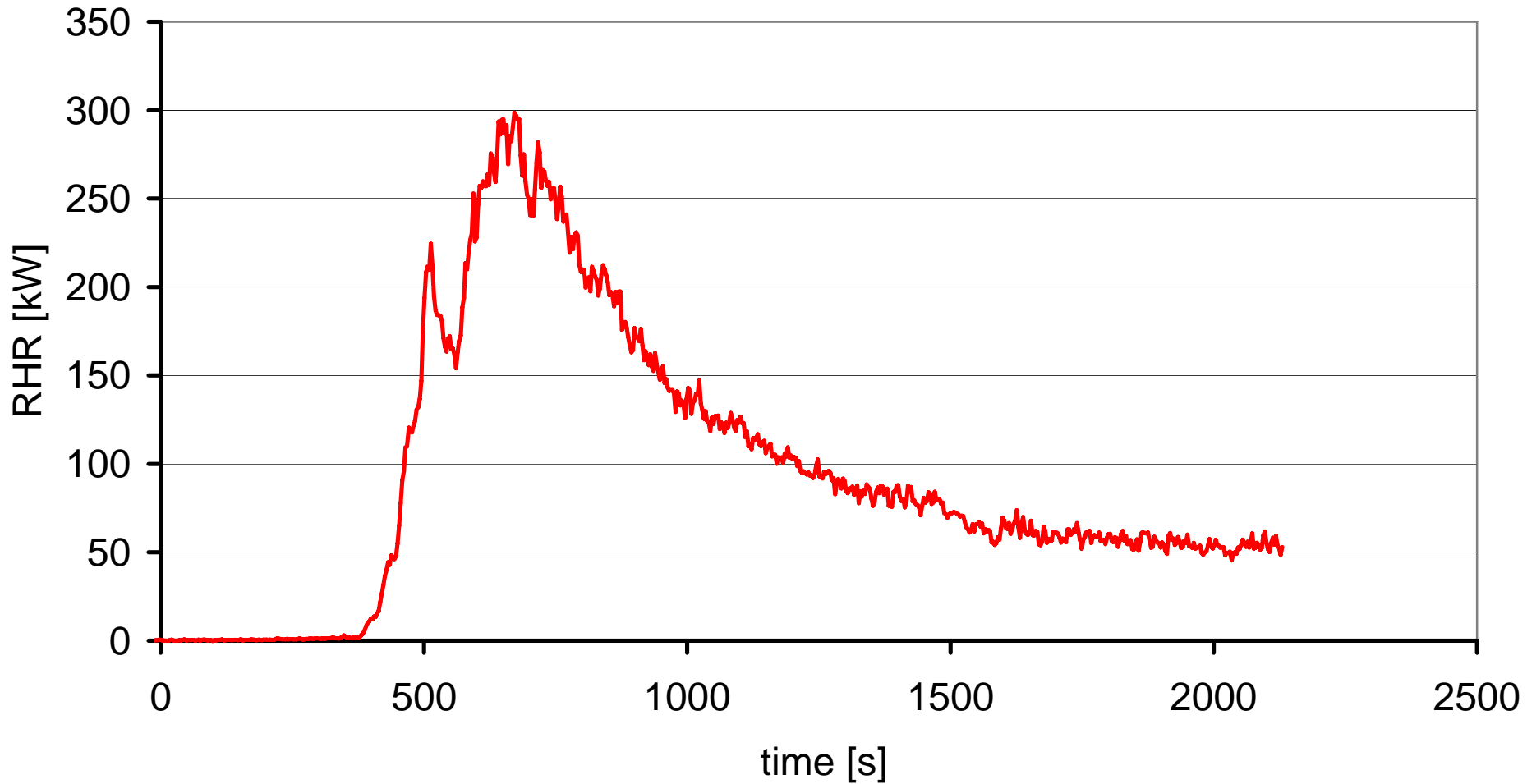
25:05 min:sec after ignition



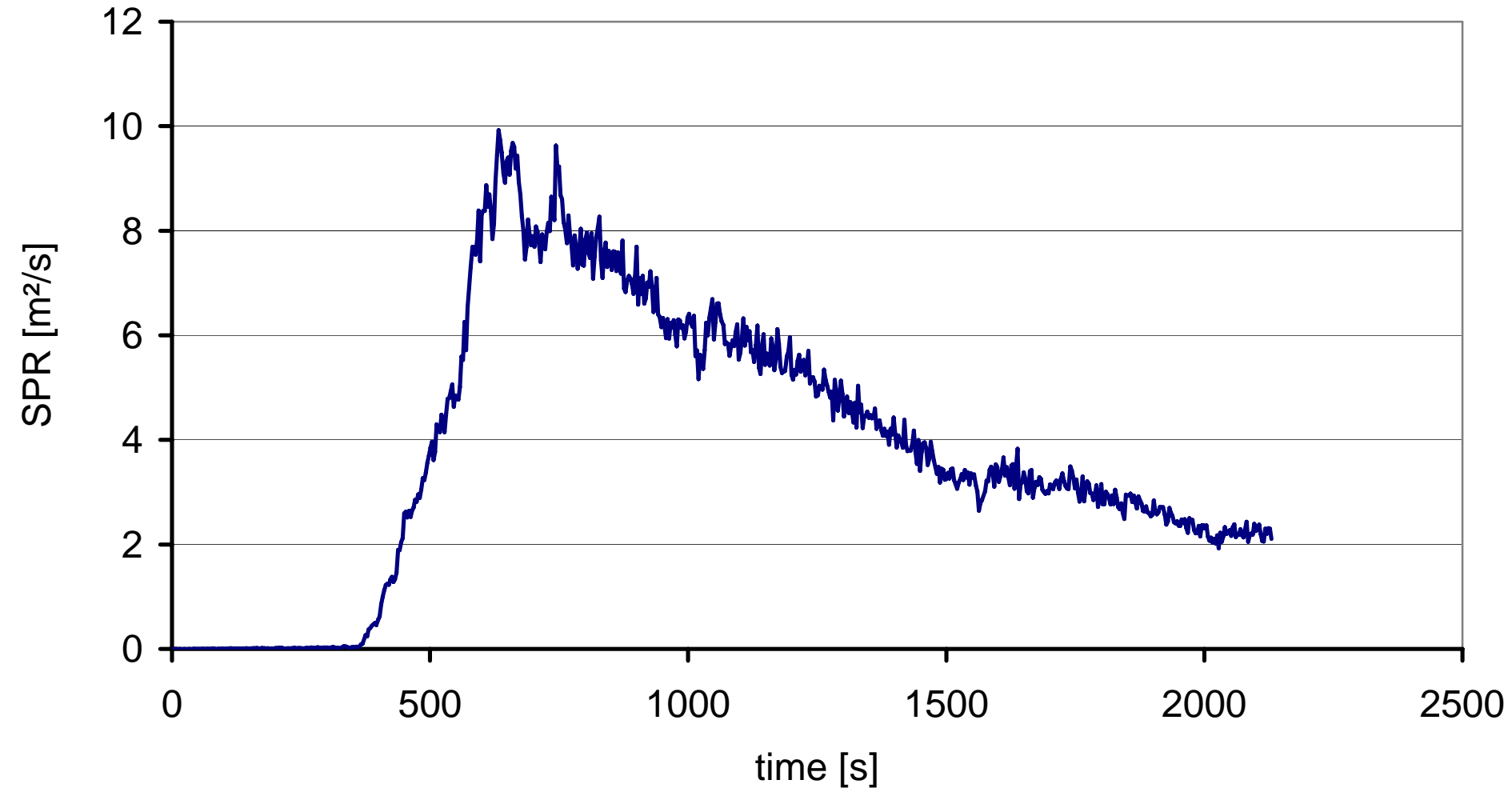
# Air Conditioner (post mortem)



# Air Conditioner – Heat Release



# Air Conditioner – Smoke Production



# Tumble Dryer (0)



# Tumble Dryer (2'02)



02:02 min:sec after ignition



04:34 min:sec after ignition

# Tumble Dryer (6'53)



06:53 min:sec after ignition



08:28 min:sec after ignition



# Tumble Dryer (12'32)



12:32 min:sec after ignition



21:39 min:sec after ignition

# Tumble Dryer (26'19)

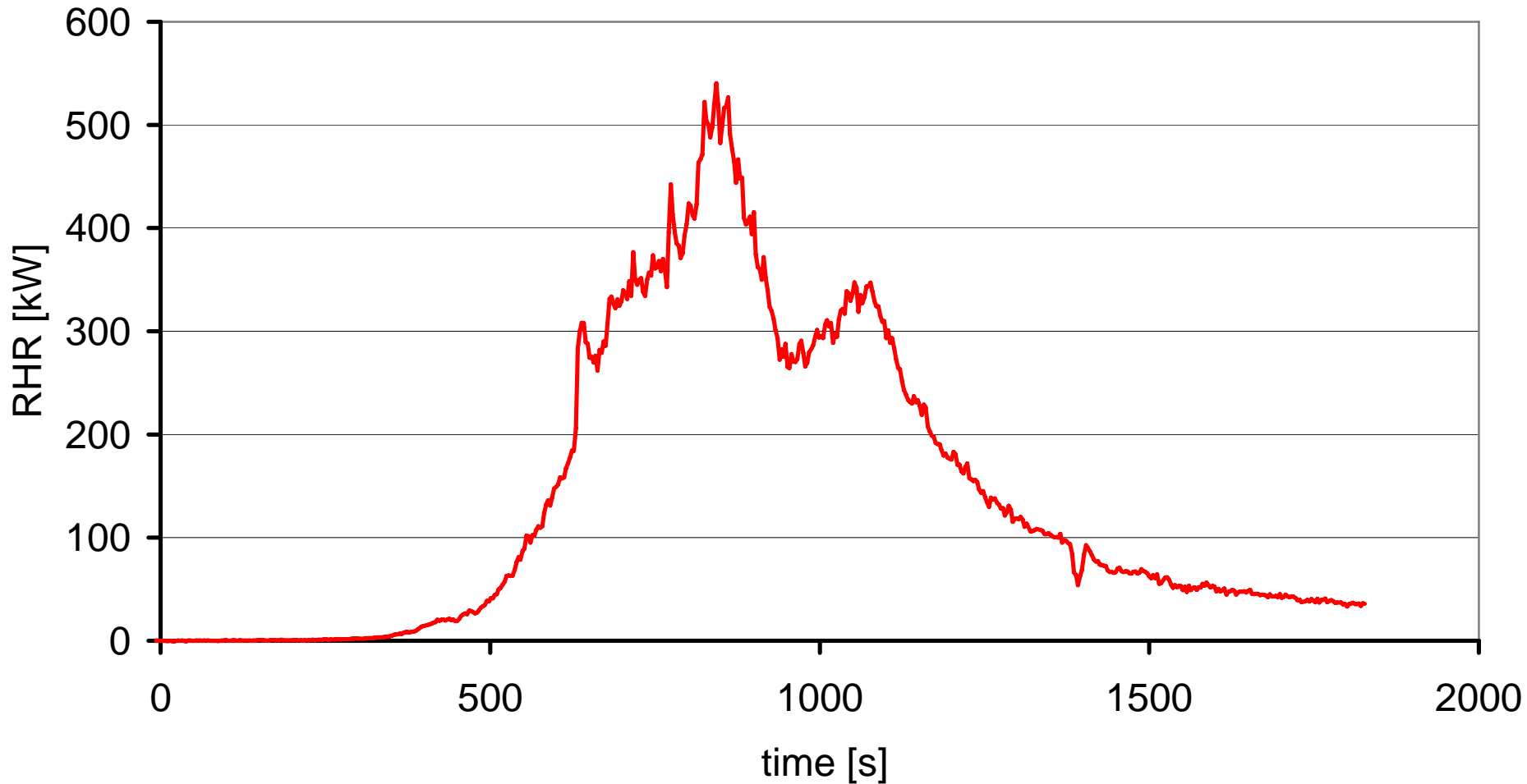


26:19 min:sec after ignition

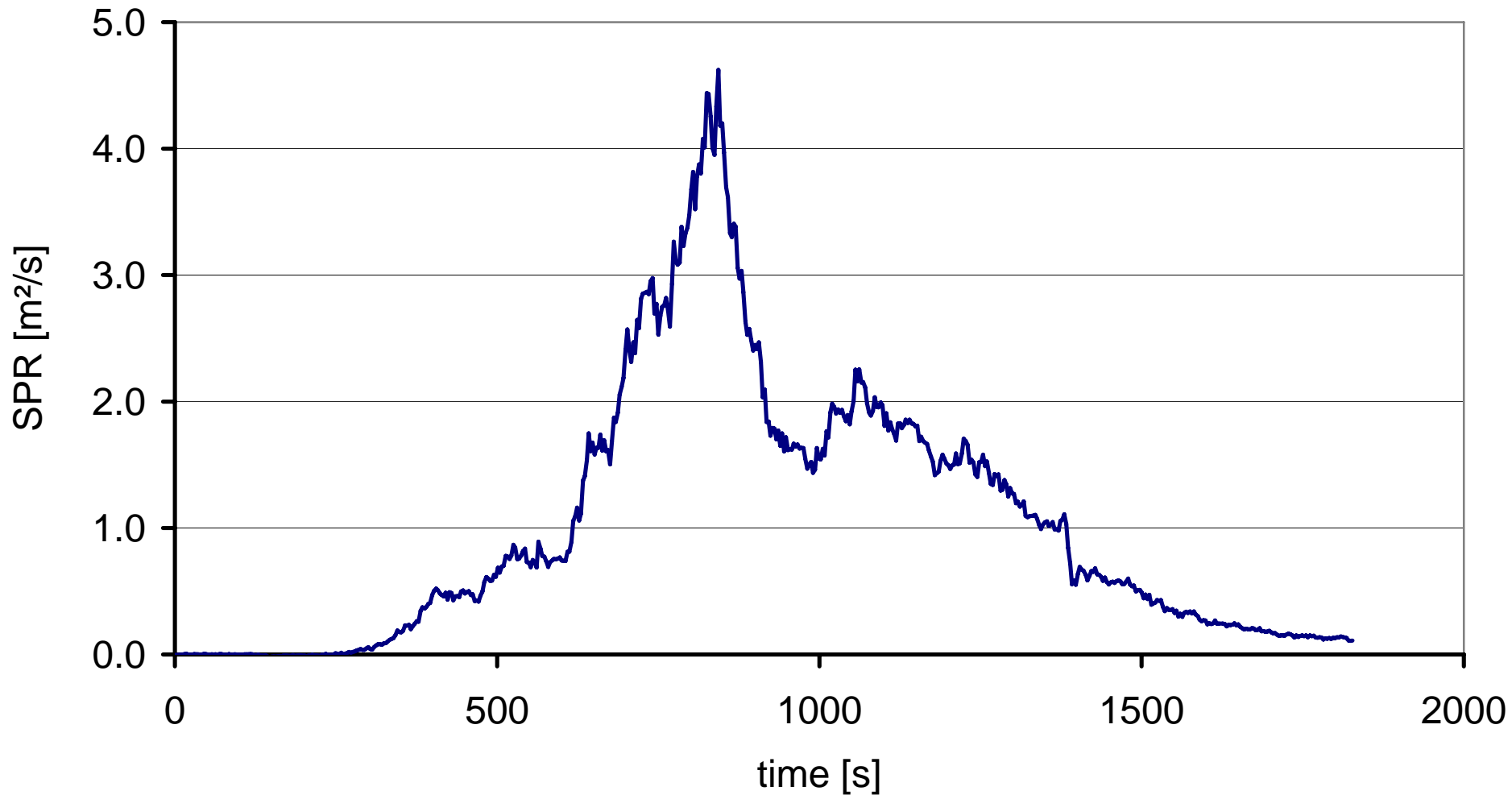


Post mortem

# Tumble Dryer – Heat Release



# Tumble Dryer – Smoke Production



# Refrigerator (0)

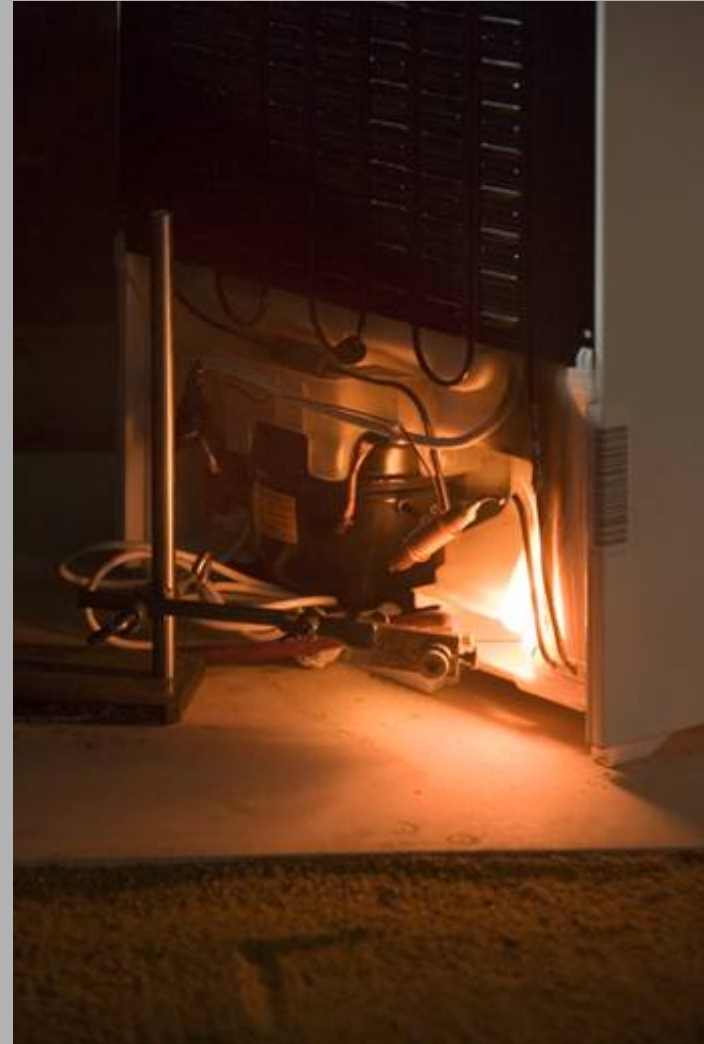


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# Refrigerator (2'20)



02:20 min:sec after ignition



03:00 min:sec after ignition



# Refrigerator (5'11)



05:11 min:sec after ignition



05:58 min:sec after ignition

# Refrigerator (6'43)



06:43 min:sec after ignition



07:53 min:sec after ignition

# Refrigerator (12'10)



12:10 min:sec after ignition



17:41 min:sec after ignition

# Refrigerator (27'46)



27:46 min:sec after ignition



28:45 min:sec after ignition

# Refrigerator (37'43)



37:43 min:sec after ignition



40:16 min:sec after ignition

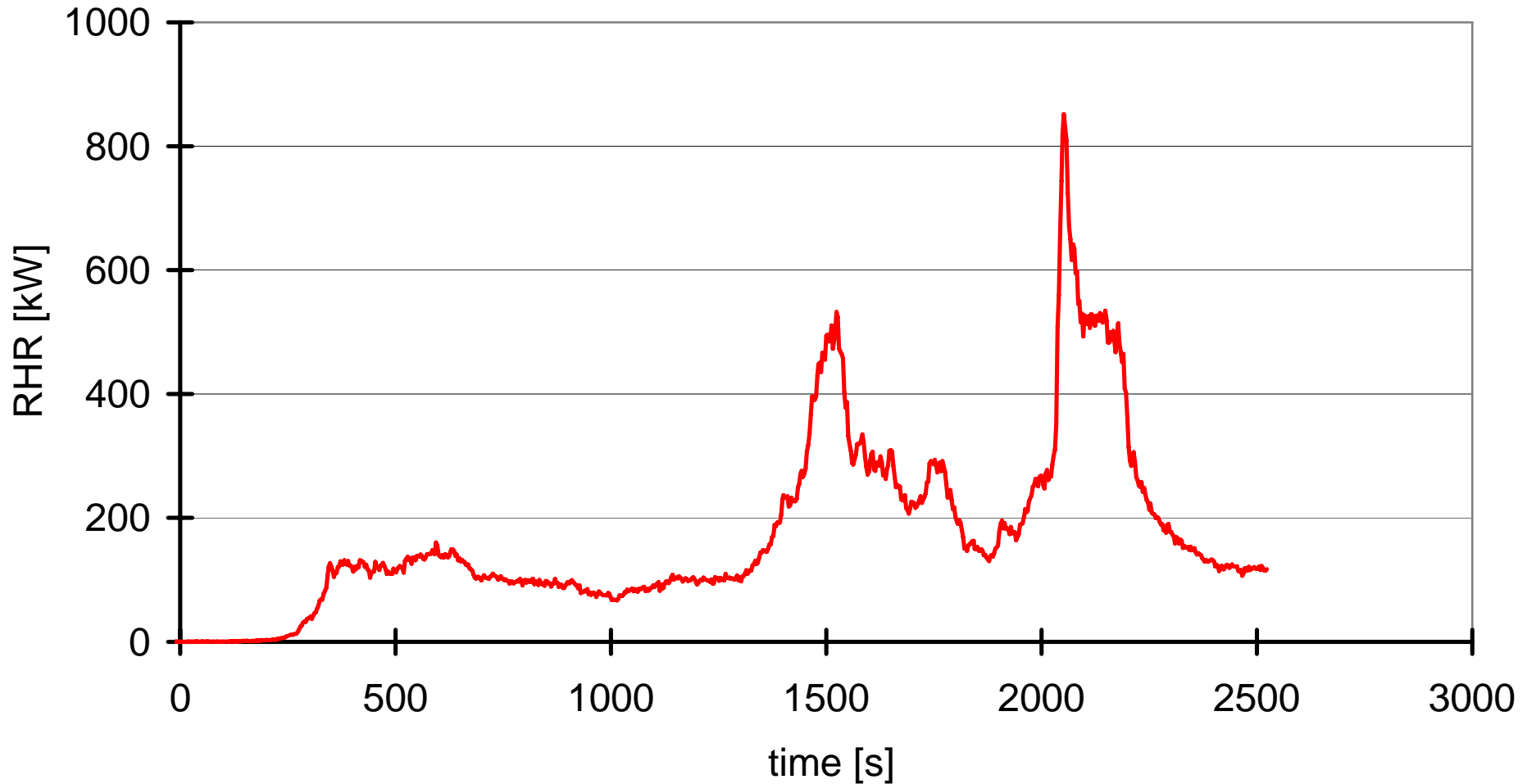


# Refrigerator (post mortem)

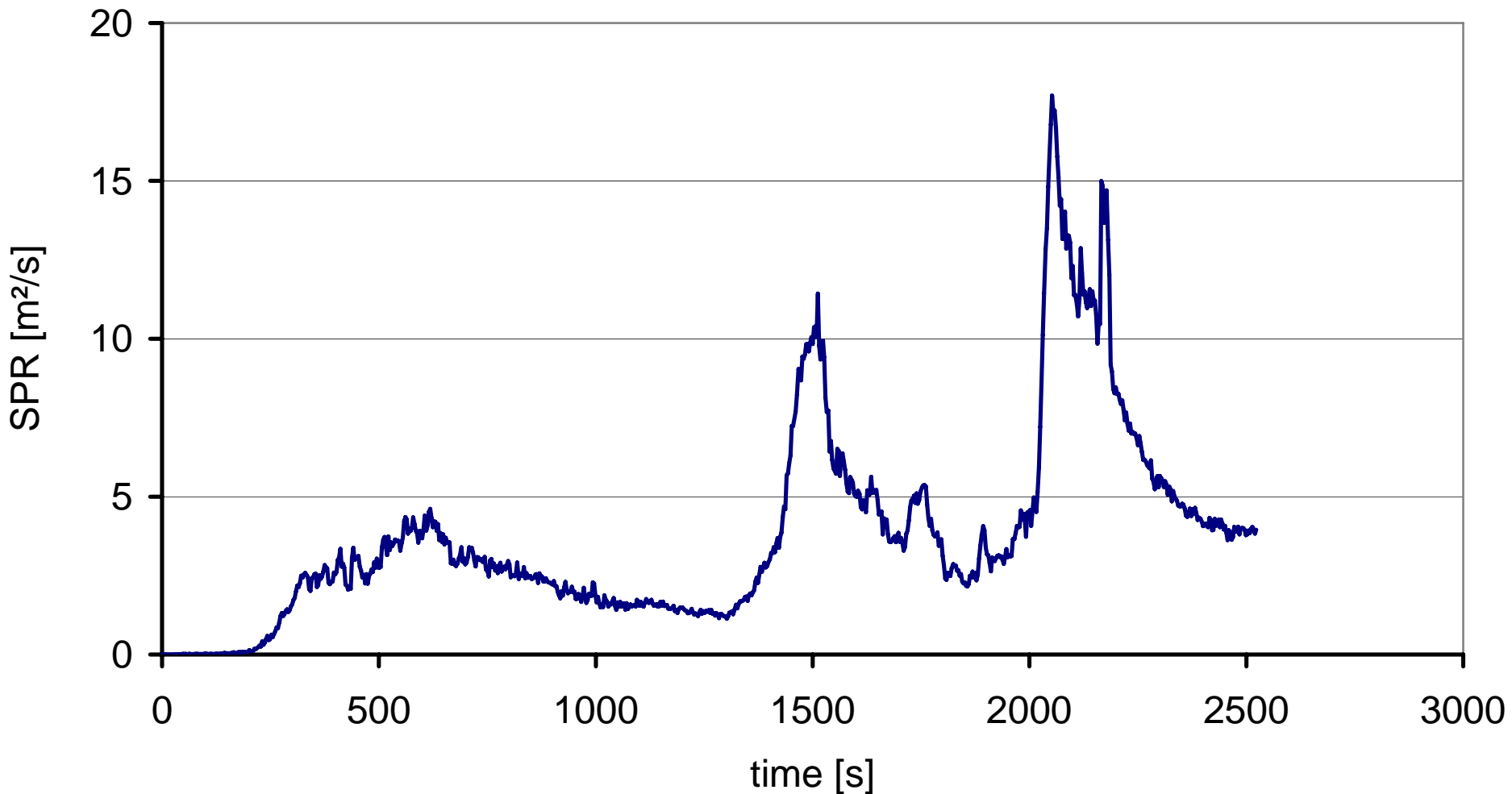




# Refrigerator – Heat Release



# Refrigerator – Smoke Production



# Conclusion

- All tested items were easy to ignite and produced considerable amounts of heat and smoke.
- Visual impressions and measured data show that small flame ignition poses a definite fire risk to household appliances.
- It is planned to use the test results for fire scenario modelling to evaluate fire risks in a home.



Thank you for your attention!

